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An Automated Conversation System Using Natural Language Processing (NLP) Chatbot in Python

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Abstract: The purpose of this project is to build a ChatBot that utilises NLP (Natural Language Processing) and assists customers. A ChatBot is an automated conversation system that replies to users' queries by analysing them using NLP and assists them in every way it can. In this project, we are trying to implement a customer service chatbot that tries to converse and assist the user in some simple scenarios. This chat bot can take simple user queries as input, process them, classify them into one of the existing tags, and respond to them with an appropriate response. If the user's queries are too complex for the bot, it will redirect the conversation to an actual person. The ChatBot is going to be based on a machine learning model that is built using PyTorch (Python Deep Learning library) and NLTK (Natural Language Tool Kit). The model used here is a feed-forward neural network. There are 3 layers in this neural network, i.e., the input layer, the hidden layer, and the output layer. The number of nodes in the input and hidden layers depends on the total number of distinct words present in the data set, whereas the output contains the same number of nodes as the number of distinct tags the data set is divided into. This kind of neural network is perfect for building simple chatbots as it does not require high computational power either for training or for deploying. The chatbot we built is for a coffee shop, and it performs actions like ordering coffee, telling a joke, suggesting a drink, etc. Although this chatbot is relatively simple, it is highly customizable, thus making it easy to implement it in any scenario.

Key words: Automated Conversation System, Natural Language Processing (NLP), Chatbot, and Python.

One of the main features of this ChatBot is that the dataset it is trained on is easy to customise and we can add new tags easily, but the neural network need not be altered in most cases, making this a very

reliable model. Many chatbots similar to this are being used in fields like medicine, government agencies, automated food ordering systems, etc. This feature also makes training and testing the chatbot very easy to customize.

Introduction:

Traditional chatbots were usually hardcoded for very specific scenarios [1]. This lack of flexibility and almost zero customization meant that the performance of these chatbots was really low [2-11]. To overcome this, we have designed a simple but effective chatbot system that anyone can easily customise for their personal use without compromising on the performance of the chatbot too much [12-16]. Using machine learning instead of hardcoding the chatbot adds many possibilities for the implementation of the bot [17-22]. Existing chatbots are either hardcoded to only converse in a limited sense or really large general-purpose chatbots that are trained on huge datasets for research purposes [23-33]. Due to this, there were not many chatbots that were actually being used or the ones that were implemented were not performing up to the mark [34]. The model we designed is as simple as a hardcoded chatbot but is far more capable. Since it's trained on a dataset that contains ideal conversations, it is more oriented towards engaging the user in a conversation [35-41]. The chatbot can also be easily extended to perform various tasks like ordering food, telling time, or booking a cab by utilising various APIs [42-55].

This project has a wide variety of applications in numerous fields, and the one we have focused on in this project is a simple cafeteria [56-71]. Apart from that, this bot can also be trained and utilised in fields like railways, hospitals, government agencies, and online services. This project makes it easier to handle the queries of a huge number of people as most of them tend to have simple queries that can be easily answered by the ChatBot [72-81]. In the case that the chatbot cannot answer the queries, it will redirect the query and the user to a real customer support person. This is really helpful in fields where repetitive questions are asked, like customer support [82-99]. The chatbot can troubleshoot many simple problems, saving time for employees and letting them focus on larger problems. When listed out, there are a number of applications for this project because of its method of implementation, reliability, and customizability, but these are the most important ones for it currently [100-111].

Added Applications

- This project has applications in medical and engineering fields as it is just a matter of changing the dataset it is trained on [112].
- This project can also be improved time to time based on its performance, which is estimated by the user ratings given as feedback [113].
- Using a feed-forward neural network means that the deep learning model is robust.
- Although it is an automated system, it is only for assisting users and employees; it is not capable of replacing any human staff [114].
- These chatbots are not only for practical applications but can also be used for research purposes, like in understanding how learning as a process actually works [115].

Objectives

We have a clear and straight-forward goal of improving the efficiency of traditional chatbots and other automated conversation systems by building a neural network based chatbot and also by adding extra features to the existing system [116-124]. Features like sending the bill via email, swear word detection, etc. can be easily added to the project. This makes it more reliable and secure to use. It is

flexible enough to be implemented in any field as long as there is a need and a data set to train it upon [125-132]. And also, the ChatBot itself is very resource efficient as it is built using the very optimised deep learning library ‘PyTorch’. Using Python for this project has made many options available to me in terms of improving the ChatBot as the language has excellent support and many valuable libraries [133-145].

Methodology to Be Followed

This project is a fully functional chatbot that is built using Python and its libraries. The Deep Learning Model is built using the PyTorch library; the tools for Natural Language Processing were provided by NLTK (Natural Language Tool Kit) and the GUI for the application is built using Tkinter, which is also a Python library that is used for building simple GUI applications. The dataset used to train the neural network is a JSON (Java Script Object Notation) file that I created myself in order to demonstrate the flexibility and ease of customization for this project. PyTorch has a built-in function that can be used to store the model and its hyper parameters after the training is done [146-156].

Expected Outcomes

The ChatBot will converse with the user depending on the structure of the dataset that is used to train it. Any queries not understood by the bot will be redirected to staff [157-171]. This will ensure that the user gets a good experience and all their queries will be clarified [172-181].

Hardware and Software Requirements

- ✓ PC with Minimum of 4GB RAM II
- ✓ 64-bit Operating system
- ✓ Windows 7 or higher / Mac OS X or higher

Software Requirements:

- Visual Studio Code IDE II
- Python 3.6 or above
- NLTK and ‘punkt’ package
- PyTorch 1.12.0 (with or without Cuda toolkit) V JSON Library

NLTK – Natural Language Tool Kit

It is a free and open-source Python library that is extensively used in NLP (Natural Language Processing). It provides various methods, functions, and prebuilt models that can be used to perform various text and language analysis operations [182-192]. It is widely used in building all kinds of text, language, and sentiment analysis machine learning models [193-195]. It is using NLTK in this project for performing tokenizing, stemming, and the creation of bags of words. These operations are performed with the help of a special NLTK package called "punkt". The functions that perform these operations are written in the following file [196-199].

Utils.py

This file contains the functions that we created to perform tokenizing, stemming, and bag of words creation. The methods are obtained from a module in NLTK called PorterStemmer [200].

JSON

JSON is a library that comes with any standard installation of Python that allows us to deal with.json files [201-203]. This file format is extensively used on the internet for sharing information because of

its well-structured way of storing data. In this project, the data set we have used to train the neural network is also a.json file. The JSON library comes with many methods and functions that allow us to easily access, manipulate, and even create.json files. Usually, the json.load function is used to load the contents of a.json file into a Python dictionary and vice versa can be done using the json.dump function [204-205].

Tkinter

Tkinter is a Python library that is used to build simple GUI applications. It comes with various functions that make the process of creating and customising a graphical user interface easier. It provides various widgets and features that make it the best choice for building practical applications and demo interfaces. In this project, we have used this library to create a graphical interface that the user can use to interact with the chatbot. This makes it easier for the user to use the chatbot, as additional features are provided in the GUI.

PyTorch

PyTorch is a free and open-source tensor library for the Python language that is widely used in building various deep learning and neural network models. It contains various modules and APIs that make it extremely handy when creating these machine learning models. It is also preferred when building NLP models when compared to other libraries. Being a fully open-source library, it is constantly being updated and improved by thousands of people who use it every day. This is one of the reasons it is the most popular deep learning and tensor library. In this project, we have used PyTorch to build the Feed-Forward Neural Network for the ChatBot. This neural network will be trained on the.json dataset and will be saved using PyTorch's own "save" function. The neural network we built contains 3 layers, i.e., an input layer, a hidden layer, and an output layer. The input layer has the same size as the total number of distinct words in the entire dataset. The hidden layer was tested with many values and was finally set to 8. The output layer's size is the same as the number of different tags the patterns in the dataset are divided into. PyTorch makes the process of building a deep learning model a little bit easier and also provides excellent ways to alter the model just by altering the hyper-parameters.

Dataset

A dataset is an accumulation of useful data that may or may not be structured and can be used to train machine learning and deep learning models to perform various tasks. There are many different factors that affect the reliability of a dataset, like the quality of the dataset, the size of the dataset, the variety of data and also the sources that generated this data. These factors are as important as the efficiency and performance of a machine learning model in a project. A good dataset can give great results for any machine learning or deep learning project. Datasets can also be artificially generated to test ideal case scenarios, but for real world applications, naturally generated datasets are used.

In this project, we have used a.json format dataset in order to train the feed-forward neural network for the chatBot. The dataset was built by myself by referring to some datasets that we found on Kaggle. All the data that is needed for the model to train, predict and respond to queries is present in the 'intents.json' file. This file contains all the data in the form of "tags," "patterns," and "responses." "tag" is the specific tag to which the pattern sentences belong. 'patterns' contains the sentences that are used to train the model so that it can classify input sentences to the appropriate tag."Responses" contains the sentences that are used to train the model so that it can classify input sentences to the appropriate tag." various sentences, among which one will be randomly selected to respond to the user's queries. If the input sentence is classified into some tag, then the responses under that tag will be used by the ChatBot. They are structured similarly to Python dictionaries, with lists inside them.

Hence, when the json file is imported, the data is stored in a python dictionary variable by using the function ‘json.load’. Given below is a snapshot of the dataset used to train this model (figure 1)

```
{
  "intents": [
    {
      "tag": "greeting",
      "patterns": [
        "Hi",
        "Hey",
        "How are you",
        "Is anyone there?",
        "Hello",
        "Good day"
      ],
      "responses": [
        "Hey :-)",
        "Hello, thanks for visiting",
        "Hi there, what can I do for you?",
        "Hi there, how can I help?"
      ]
    },
    {
      "tag": "goodbye",
      "patterns": ["Bye", "See you later", "Goodbye", "bye bye"],
      "responses": [
        "See you later, thanks for visiting",
        "Have a nice day",
        "Bye! Come back again soon."
      ]
    },
    {
      "tag": "thanks",
      "patterns": ["Thanks", "Thank you", "That's helpful", "Thank's a lot!"],
      "responses": ["Happy to help!", "Any time!", "My pleasure"]
    }
  ]
}
```

Figure 1: JSON file Structure

GUI Application

The GUI for the ChatBot is built using the Tkinter library. The interface is intentionally kept simple but is functional enough to work without any major problems. The interface consists of two main components. One is the chat log, where the messages of both the bot and the user are present, and the other component is the message entry box and send button. The interface is simple to use and works without any errors or bugs. The size of the entire interface is 1000 x 800.

Chat Log

This component displays the entire conversation between the user and the ChatBot. The log is stored as long as the current conversation has not ended. The Chat Log also has a scroll feature if the conversation becomes very lengthy. Above the chat log is a small label that contains the message "Welcome". This can be customised to any title suitable for the purpose and behaviour of the ChatBot. The messages in the log will be sent to the staff if the bot is unable to assist the user and the conversation is also redirected to the staff.

Message Entry Box and Send Button

In order to take the user's input, a message entry box is added to the interface. The user can enter the message in the entry box and press 'enter' to send it. There is also a dedicated 'Send' button beside the message entry box that works in a similar way to pressing 'enter'. The widget is also programmed to discard any empty or unnecessary "enter" inputs (figure 2).

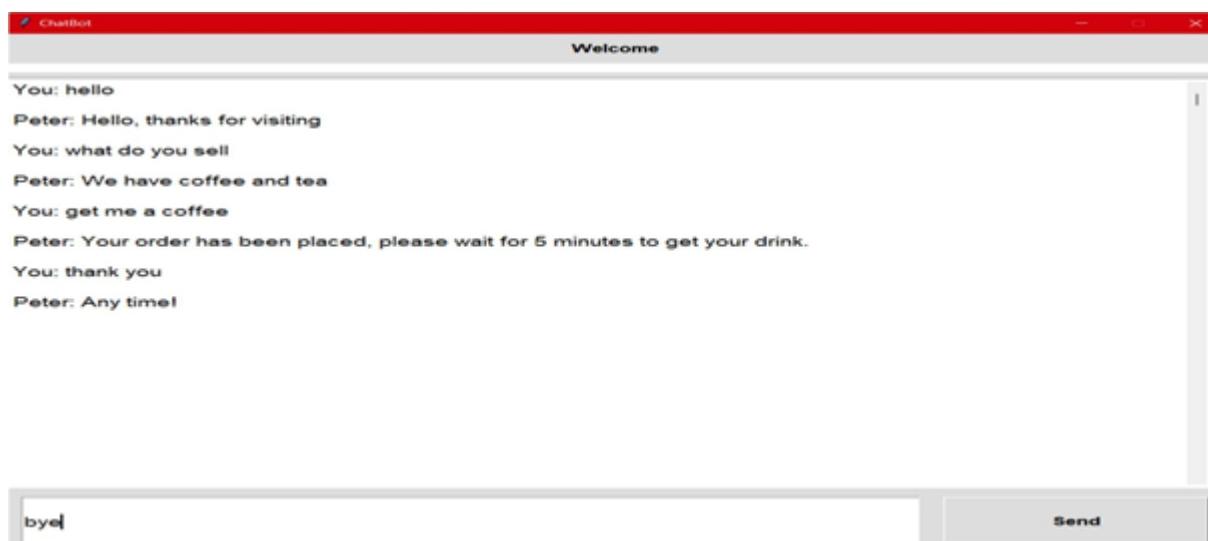


Figure 2: ChatBot GUI Layout

Implementation

Module 1: Neural Network

First of all, a stable version of the PyTorch library must be installed, either with or without the cuda tool kit and GPU support. And then import the Torch library and the Torch.NN module in order to build the neural network. The model code is present in the ‘model.py’ file. The module torch.nn gives us a blueprint for building a neural network in a class format. We have extended this class with additional specifications and parameters. The class we created, i.e., NeuralNet, extends Torch.NN and also takes input size, hidden size, and the number of different tags as input during object creation. The neural network itself has three layers, i.e., the input layer, the hidden layer, and the output layer. The input layer has the same number of nodes as there is a total number of distinct words in the dataset. The hidden layer size was tested with varying values, and in the end, we decided to take the value of 8 as it seems to perform well. The output layer has the same number of nodes as there are different tags in the dataset.

The activation function between the layers is the Rectified Linear Unit (ReLU). It is a commonly used activation function in neural networks that returns the output of a node if it is positive, and returns 0 if the output value is negative. And a SoftMax activation function is applied to the output layer of the neural network. The outputs of a neural network are independent probabilities, making it tough to classify the output properly. The SoftMax activation function takes the output of all the notes and returns mutually exclusive properties, allowing the neural network to properly classify the sentence into an appropriate tag.

Module 2: Training and Hyperparameters

Since the dataset was created by me, no preprocessing is required. The data is also present in a structured format. This makes the training process somewhat easier. In training the model, all the necessary libraries are imported, i.e., numpy, NLTK, PyTorch, random, JSON, and also the ‘model.py’ into a python file called ‘training.py’. Before this, in a separate file, the code for operations such as tokenizing, stemming, and creation of bags of words was written by importing the NLTK library. This file is named ‘utils.py’, which is also imported in ‘training.py’. The data is extracted from the ‘intents.json’ file and all the different sections, i.e., tags, patterns, and responses, are stored separately. A new class called ChatDataset is created and the data is stored in this format.

A few methods to access the data are also created for this class to make training the model simpler. After this, an object of the NeuraNet class is created with the appropriate hyperparameters. Once the object is created, the dataset is loaded using the DataLoader function of the Torch library along with a few parameters and hyperparameters. The device for training, i.e., either a CPU or GPU, is selected based on its availability. CrossEntropyLoss is the loss function, and the Adam optimizer is selected for model optimization. The model is trained and goes through the dataset as many times as the value of the ‘num_epochs’ hyperparameter. After the training is done and if the final loss is found to be satisfactory, the trained neural network model and its hyperparameters are stored in the ‘data.pth’ file using the torch.save function to use the model in the Chat Interface.

Module 3: Graphical User Interface

The main objective of the graphical user interface is to make interacting with the chatbot much simpler than just using the terminal. This is achieved using the Tkinter library and its modules. The interface we built for the chat bot is simple but elegant and very functional. The interface has no errors or bugs, making it hassle-free. There are two main components in the graphical interface. One is the Chat Log, which contains the entire conversation between the user and the bot. This makes it easier to follow the conversation if the user's query is too complex for the bot and is redirected to staff. The staff member has to just go through it once in order to reply. The second component is the message entry box and send button. This helps in taking the user's query in a proper format that is more appealing to the user. The send button is used to send the user-entered text as input to the bot. Pressing ‘enter’ also performs the same action as pressing the send button.

Results and Other Added Features

The results exceeded my expectations for the ChatBot. The performance of the bot, both technically and practically, was really impressive. After testing with a couple of other data sets obtained on the internet, the performance of the bot was surprisingly good on the other datasets too. The changes were made to the model by only using the hyperparameters when training on other datasets. The neural network model used is simple to understand but is complex enough to implement on large datasets.

It added a couple more features, i.e., a fully functional GUI, a proper user feedback query at the end of every conversation, and also the function to send the bill of every order to the user's email if they choose. Any other extra features or tags can be easily added to this ChatBot. In most cases, it only requires a change in the dataset, which can be done by any non-programmer. But implementing a new technical feature requires programming knowledge but is relatively simple considering the Python language has good community support and a large number of libraries and APIs that are actively supported. And when the ChatBot is unable to understand the user query or classify it into at least one of the given tags, the conversation is redirected to a human support person. This means that the conversation is never interrupted on the user's side, and their issue is resolved a maximum number of times. This means that the overall customer satisfaction regarding the ChatBot is also very high (figure 3).

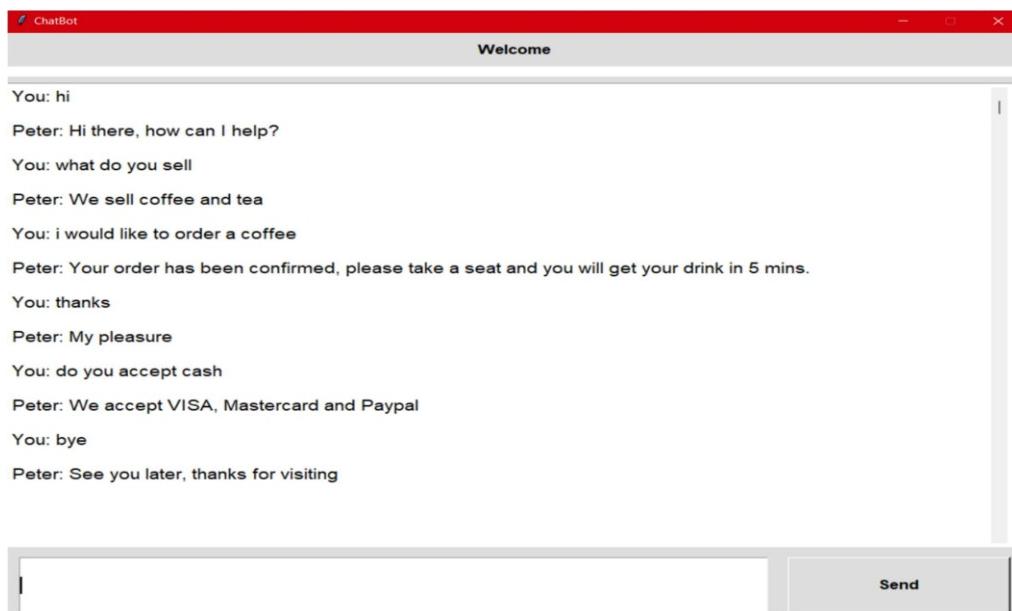


Figure 3: ChatBot Final Result

Conclusion

It had a clear vision of how the project was supposed to work, and the results matched and exceeded my expectations. Usage of the Python language meant that including extra features was simple and effective. Many of the previously existing chat bots were hardcoded, but in this project, it has used Natural Language Processing and Deep Learning in order to build a simple but automated conversation system that can be easily trained and implemented in any field. The implementation of this project is in such a way that it can be customised and altered endlessly. Since the behaviour of the chatbot is dependent on the dataset, its implementation in any field is possible as long as relevant data is available. Also, adding extra features is very easy because of this implementation.

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